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HAZARDS EVALUATION FOR DISASTER PREPAREDNESS PLANNING

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This booklet has been reviewed in the Defense Civil Preparedness Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Defense Civil Preparedness Agency. This document has been approved for public release; its distribution is unlimited.

HAZARDS EVALUATION FOR DISASTER PREPAREDNESS PLANNING

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WHY WORRY NOW?

A multitude of pressing "here and now" matters compete for the attention of public officials. With no shortage of squeaky wheels demanding grease, it is small wonder that officials and their staffs would rather not use their precious time to worry about disasters that haven't happened yet -- and perhaps never will.

BUT -- all it would take would be one major disaster. Then, without warning, the everyday problems would be shoved onto the back burner while governments tried to cope with chaos. Planning to mitigate or eliminate the hazards that lead to disasters, together with disaster preparedness planning, is valuable insurance against being overwhelmed by catastrophe.

A METHOD FOR EVALUATING HAZARDS

Before anyone can plan how to deal with potential disasters, the hazards that can lead to these disasters must be identified and priorities for action must be assigned. Hazards evaluation is important to every local and regional government agency in the San Francisco Bay Area. That is why the Association of Bay Area Governments (ABAG), under the sponsorship of the Defense Civil Preparedness Agency (DCPA), prepared the guide to hazards evaluation on which this booklet is based.

The principal objectives of ABAG and the DCPA in preparing the guide were to:

- Outline for local governments a method for identifying hazards that are most likely to lead to major disasters in their jurisdictions.
- Suggest some relatively simple methods for evaluating and ranking hazards.
- Present some possible guidelines for establishing priorities for hazard reduction or elimination.

Since most of the information presented in the guide is common knowledge, why was it desirable to prepare the guide at all? The answer is that the guide:

- Gives some common definitions for describing hazards and disasters.
- Suggests some uniform methods for comparing and evaluating hazards.
- Offers a simple basis for presenting findings so that preparedness planning priorities can be established.

The guide can be used as part of a Federal/State "On-Site Assistance" (OSA) program in which the evaluation effort is shared among local governments and other supporting agencies. It can also be used independently by local governments to deal with problems unique to their jurisdictions.

THE APPROACH

It was important to develop a guide that could be used specifically for brief, qualitative evaluations, which are often best suited to the needs and budgets of local governments. Therefore, the guide was developed within these parameters:

- The method is essentially qualitative.
- Only hazards that can lead to major emergencies or disasters are addressed.
- Chronic and routine problems of government are excluded from consideration.
- Evaluation criteria include history, vulnerability, maximum threat, probability, and risk.
- Each criterion can be evaluated independently of the others, but the results of all evaluations can be integrated to provide an overall picture.

The guide suggests rating techniques and gives examples of methods for summarizing results. Suggestions are also given for decision rationales that can be adapted to the special needs of officials who must establish civil preparedness priorities for their jurisdictions.

For more detailed (quantitative) evaluation methods, the reader is referred to the Bibliography presented at the end of this document. Of particular interest are: The "Urban Geology Master Plan for California" (Ref. 2); References 4 through 8; and References 10 and 11.

SOME DEFINITIONS

The guide focuses on hazards -- sources of danger -- that could lead to major disasters in the Bay Area. It is not concerned with day-to-day governmental problems that are handled by standing regulations as routine business, nor with minor problems that do not call for the use of special powers or for extraordinary emergency governmental response.

Disasters

In the guide, disasters are defined as events that do call for substantial emergency response and that do require the use of extraordinary governmental powers. Disasters include events in which several emergency services (fire, medical, etc.) in one jurisdiction must make a coordinated response, as well as events for which emergency services from several jurisdictions are needed. Disasters also include events such as major storms and earthquakes that affect a large area and call for a coordinated response from many jurisdictions and agencies.

Emergency versus routine powers

Routine Powers

Cities and counties are on equal level

Joint powers agreements may be used

Use of government funds is closely prescribed

Private rights are prescribed by Constitution

Legislative process cannot be shortcut

Emergency Powers

County may become "operational area" over city

Master Mutual Aid Agreement may be used

All government funds can be tapped for disaster use

Public rights can supersede private rights

Legislative process can be shortcut

Hazards

To simplify the discussion, hazards are named for the disasters they may precipitate. For example, "earthquake hazard" includes the complex inter-relationship of active faults, weak geological formations, and human activity that could lead to a major earthquake disaster. Listed below are examples of the types of hazards/disasters that can be evaluated using the methods outlined in this guide.

Earthquake

Nuclear War

Landslide

Epidemic

Tsunami

Human

Animal

Plant

Flood

Flash

Fire

Slow-Rise

Urban

Rural

Storm

Wind

Civil Disturbance

Hail

Wreck

Utility Failure

Aircraft

Electrical

Train

Gas

Ship

Water Supply

Multivehicle

Dam/Levee Failure

Building Collapse

Pollution

Pollutant Spill

Air

Chemical

Water

Nuclear

Oil

DESCRIBING HAZARDS AND DISASTERS

Ten questions form a basis for describing hazards and disasters. The answers to these questions can be displayed in tabular form, so that officials can see at a glance not only what the problem is but also what some of the important parameters are.

1. What Causes the Disaster?

Disasters may be caused by natural forces such as storms, or by human activity (aircraft crashes, for instance), or by a combination of natural and human forces (as with air pollution). If the cause is known it may be possible to reduce the hazard or to find better ways of dealing with the disaster.

2. How Does Damage Occur?

Injury and death to humans and animals are caused by the release of energy, by poisoning (chemical or nuclear spills, air pollution), or by drastic changes in the environmental conditions (freezes, heat waves). Property is usually damaged through the release of potential energy (flood, earthquake, fire). It may also be damaged through contamination (e.g., from an oil spill).

3. Are There Seasonal or Other Time Constraints?

Time constraints are often associated with specific hazards. In the Bay Area, flooding is associated with winter and wildland fires with summer. We generally recognize the seasonal nature of important hazards and plan accordingly.

4. Are There Geographical Constraints?

Some hazards are associated with geographic location or with land elevation. Tsunamis potentially threaten some coastal and low-lying bayside areas; landslides tend to occur on geologically weak formations. In contrast, an aircraft crash, which could happen anywhere, is geographically unconstrained.

5. What is the Geographical Extent of the Disaster, and Where is its Effect Most Intense?

Some disasters, such as a winter storm, affect a broad area of many square miles, but others (landslides, for instance) affect only a few acres. Damage from the first type of disaster may be spread relatively uniformly throughout the affected area, or it may be spotty -- there could be intense damage at some locations and little or no damage at others. Earthquake damage tends to be spotty, while air pollution effects tend to be more uniform.

6. Can an Imminent Disaster Be Forecast?

Some forecasts of disasters can be made, and advisories can be issued, if we know something about the conditions that increase the likelihood of the event. Heavy snow in the mountains, coupled with an unseasonable warm spell, probably means floods. Rapidly falling barometric pressure usually precedes high winds; prolonged periods of high temperatures and low humidity mean wildland fires are more likely, and so on.

7. Is There a Warning Period? If So, How Long is It?

Warning is critical for protecting life and, sometimes, property. Protection measures and actions are often determined by the available warning time. For certain disasters -- train wrecks, for example -- little or no warning is available. In contrast, we generally have useful warning of tsunamis from distant quakes that register on equipment ashore many hours before the seismic sea wave reaches the coast.

8. What is the Rate of Onset of the Disaster?

Earthquakes, flash floods, and similar disasters often strike immediately and with great intensity. Others, such as epidemics, may gradually build to peak intensity.

9. Is the Intensity of a Disaster Predictable?

Yes, in the case of disasters such as floods or power failure; no, for disasters such as epidemics or nuclear wars.

10. How Long Will the Impact Last?

It is very hard to respond fully to a disaster while it is still running its course. A tsunami lasts for minutes, but a storm may last for days. However, the longer time periods can be used by those distant from the disaster area to assess the magnitude of effects and to mobilize aid. And for slowly developing, nonviolent disasters such as epidemics, the impact interval can sometimes be used effectively to mitigate damaging effects.

The types of disasters of concern for the Bay Area can all be described in terms of the questions listed above. (Table 2, on pages 18 and 19, summarizes these descriptions for each type of disaster as it could occur in the nine-county area. For readers who would like additional descriptive information, appendices discussing several of the more important types of disasters are available from ABAG and an example is given at the end of this booklet.)

TRIGGERING AND TRIGGERED DISASTERS

Some disasters set off other types of catastrophes in a cascade of effects that leads to a highly complex situation (see Figure 1). Table 1 gives an idea of primary (triggering) and secondary (triggered) disasters that could be of major consequences in the Bay Area. Planners should note that for their purposes it is generally more useful to consider all secondary disasters as a part of, and in the context of, the overall situation created by the primary (triggering) event.

FIGURE 1

A cascade of disasters from one triggering event

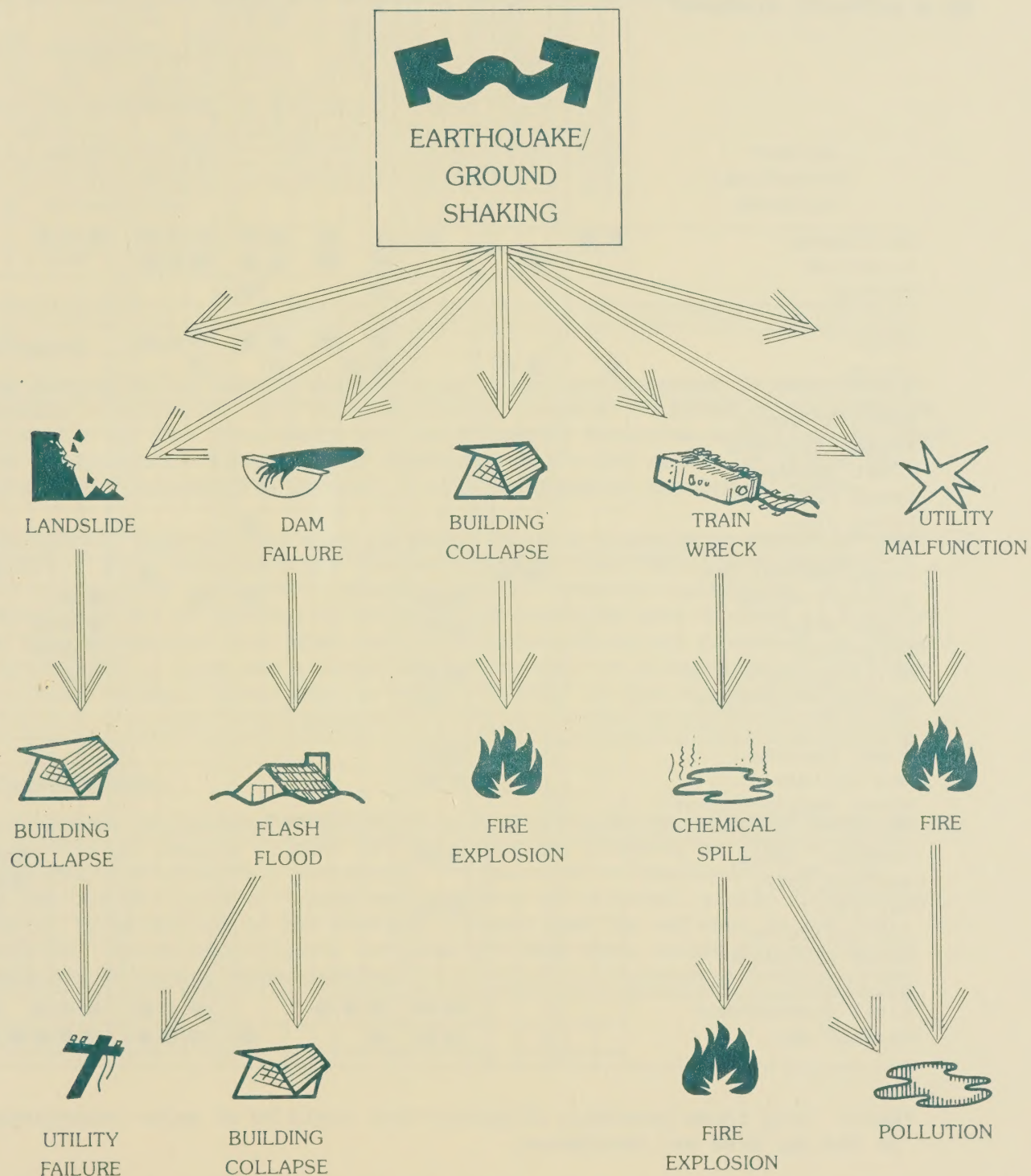


TABLE 1

**Secondary disasters
that can be triggered
by a primary disaster**

PRIMARY (TRIGGERING) DISASTER	Landslide	Tsunami	Flash Flood	Slow-Rise Flood	Rural Fire	Urban Fire	Levee/Dam Failure	Aircraft Wreck	Train Wreck	Shipwreck	Multivehicle Wreck	Building Collapse	Power Failure	Gas Failure	Water Supply Failure	Chemical Spill	Nuclear Spill	Oil Spill	Air Pollution	Water Pollution
Earthquake	●	●				●	●		●		●	●	●	●	●	●	●	●		
Landslide			●				●		●		●	●	●	●	●					
Tsunami							●					●								
Flood							●		●		●	●	●	●	●					
Storm	●		●	●			●	●			●		●							
Human Epidemic																				
Animal Epidemic																				
Plant Epidemic																				
Rural Fire																				
Urban Fire												●								
Levee/Dam Failure			●	●											●					●
Aircraft Wreck						●	●					●	●				●	●		
Train Wreck						●	●										●	●	●	
Shipwreck																	●	●	●	
Multivehicle Wreck						●	●										●	●		
Building Collapse							●													
Power Failure						●	●													
Gas Failure						●	●													
Water Supply Failure																				
Chemical Spill						●	●												●	●
Nuclear Spill																			●	●
Oil Spill						●	●													●
Air Pollution																				
Water Pollution																				
Civil Disturbance						●	●	●	●	●			●	●	●		●	●	●	●
Nuclear War						●	●	●				●	●	●	●		●	●	●	●

*Note: Only those secondary disasters that could be of major consequence in the Bay Area are considered.

Source: "Hazards Evaluation Guide," ABAG, August 29, 1975.

CRITERIA FOR EVALUATIONS

The evaluation method suggested in the guide is based on the use of five criteria for describing and assessing potential disasters:

1. History
2. Vulnerability
3. Maximum Threat
4. Probability
5. Risk

History

The history -- or lack of history -- of previous disasters is important in hazards evaluation. If a certain kind of disaster occurred in the past, we know that at that time there were sufficiently hazardous conditions to cause the catastrophe. Unless these conditions no longer exist, or unless they have been substantially reduced, a similar disaster may happen again.

But history must be used with caution. Because there is no record of specific disaster in an area does not necessarily mean that there is no hazard, and no disaster potential. Remember the San Fernando earthquake in 1971. That fault had no history of activity and had long been classed as inactive. We should remember also that our whole technical/social framework is changing so rapidly that new hazards may be created, or hitherto minor ones may increase, without these changes being recorded in the relevant history.

Vulnerability

All persons who might be killed or injured and all property that might be destroyed or damaged -- that is, all lives and property at risk -- are vulnerable to potential disasters. To describe vulnerability, one describes and/or lists all lives and property in jeopardy, giving information useful in establishing the boundary between what is and what is not vulnerable. These descriptions are also the base data needed for evaluating measures to reduce vulnerability.

Vital facilities and population groups of special concern can be identified in vulnerability descriptions. Some important classifications might be:

<u>People</u>		<u>Property</u>	
At home	In Institutions	Vital facilities	Residences
Aged	Schools	Emergency facilities	Stores and
Handicapped	Hospitals	Transportation	warehouses
Children		systems	Offices and
	In Transit	Hospitals	factories
At work		Utility systems	Inventories
		Dams	

In describing vulnerability and in determining priorities for action to reduce vulnerability, several other factors can be considered. Two important categories are these:

<u>Property Ownership</u>		<u>Economic Disruption</u>	
Private	Government	Loss of:	Loss of:
Individual	Local	employment	transportation
Corporate	State	production	communications
	Federal	profitability	

Each jurisdiction will have its own special "mix" of factors that should be described and analyzed in terms of vulnerability.

Vulnerability may vary with time. For example, a high-rise office fire during the day would place more lives at risk than would a nighttime fire. A late spring freeze could cause much more agricultural damage than would a winter freeze. Where time variability is significant, it should be incorporated in vulnerability descriptions.

Maximum threat

Maximum threat is the greatest destruction that can be expected from a disaster. Maximum threat can be expressed in terms of loss of life, injury, and property loss. To estimate longer-term economic consequences, more detailed descriptions and statistical analyses would be required.

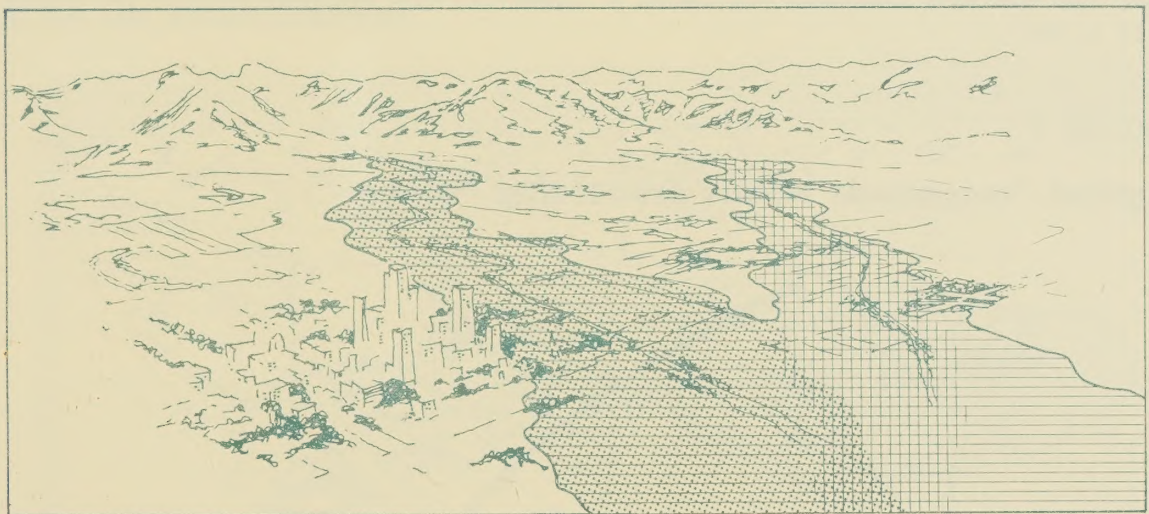
Loss of life, injury, and property loss are the critical factors in estimating emergency response needs. Emergency services are designed to be mobilized at some maximum rate, or to respond to disasters of some maximum size. In effect, the estimate of maximum threat establishes the upper size limits for emergency services design.

Some hazards may pose rather precise maximum threats -- for instance, the spontaneous collapse of a building poses a threat that is readily and accurately described. Other hazards may have complex effects and may cause instant chaos. An earthquake, for example, could simultaneously collapse many buildings and create a host of other problems (fires, gas and water main rupture, etc.). Describing maximum threat in these cases is far from simple.

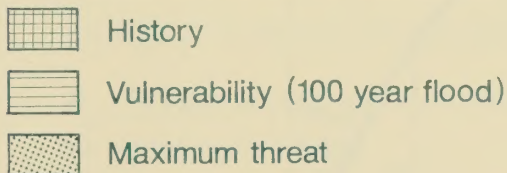
Figure 2 illustrates the concepts of history, vulnerability, and maximum threat as they apply to a hypothetical flood. The figure shows that the creek on the right has flooded in the past, that the maximum threat comes from flooding of the creek on the left (because it would inundate part of the city), and that the entire shaded area is vulnerable to flooding.

FIGURE 2

History, vulnerability, and maximum threat for a 100-year flood



Source: ABAG.



Probability

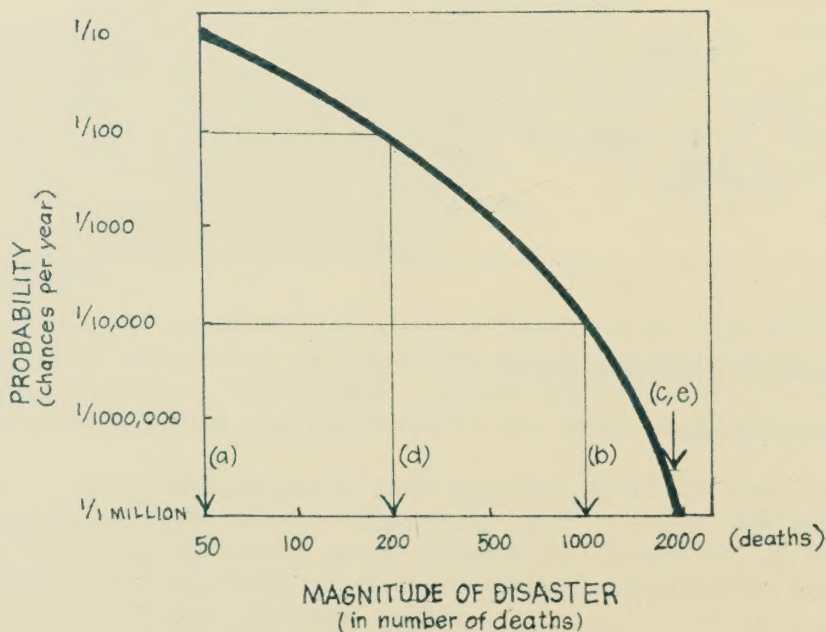
For hazards evaluation, probability is usually expressed as the number of chances per year that a disaster of a specific size (or greater) will occur. Figure 3 shows how the magnitude of a disaster can be related to the probability that it will occur. The figure can be interpreted in several ways. It shows that there is (a) one chance in ten that in the next or a future year, 50 or more people will be killed in a disaster of the type under study. Or (b) there is one chance in 10,000 that 1,000 or more people will be killed, and (c) one chance in one million that 2,000 or more will be killed.

But generating a curve in this detail for each hazard would probably cost most jurisdictions more than it would be worth for disaster planning. It is more practical to use the probability of one chance in 100 during a year; this is equivalent to the 100-year event.

Let us assume that Figure 3 refers to the hazard to ground population posed by the (potential) crash of a large plane. The figure shows (d) one chance in 100 that in a future year a crash will kill 200 or more people, and (e) that the maximum credible accident -- that is, the maximum threat -- could kill 2,000.

FIGURE 3

Typical "magnitude versus probability" curve

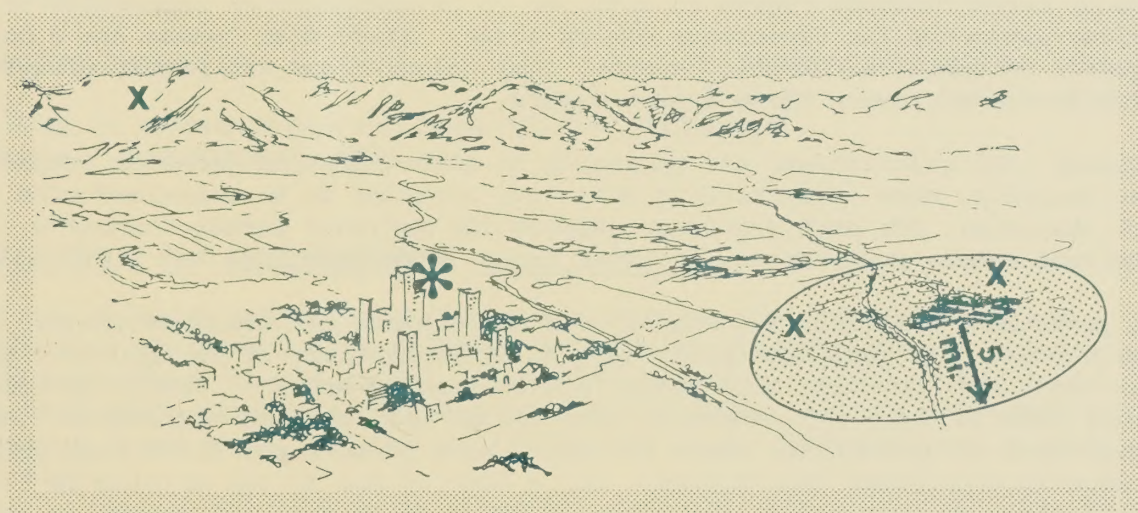


For those who would like more details concerning probability calculations, Rasmussen (Reference 4) has an excellent discussion. The probability of occurrence of the most severe disaster, nuclear attack, cannot be calculated by any generally accepted method. However, for civil protection planning and hazard evaluation purposes, the probability of a nuclear attack upon the Bay Area is assumed to be less than one chance in 100 per year and may be less than one chance in 1,000.

Figure 4 illustrates the concepts of history, maximum threat, and probability as they apply to air crash. The figure shows that three disastrous crashes have happened in the past, that the maximum threat is to the large building in the center of the city, and that the probability of a disastrous crash within 5 miles of the airport is significant, but that the probability is nil beyond the 5-mile radius. Not shown, but obvious, is the fact that all areas are vulnerable to air crashes.

FIGURE 4

History, maximum threat, and probability of an air crash disaster



- X History of past major crashes
- * Maximum threat
- Probability - nil
- ▨ Probability - significant

Source: ABAG.

Risk

Risk from a hazard is expressed as the expected loss rate (usually given in terms of average loss per year). Risk is calculated by multiplying the estimated or historical magnitude of the consequences of an event by its estimated or historical frequency or probability. For instance, the probability of an 8.3 Richter magnitude earthquake in the Bay Area has been estimated at one per 170 years (see Reference 3). It was also estimated that, with a total population of 5 million in the area, there would be about 6,600 deaths from such a quake. With these figures, the annual risk of death from this size of quake can be calculated:

$$\text{Risk} = \frac{6,600 \text{ deaths}}{5 \text{ million population}} \times \frac{1 \text{ quake}}{170 \text{ years}} =$$

7.7 deaths per year per 1 million persons

Risk calculations have some value in establishing planning and action priorities, but they cannot be used alone as a basis for deciding on an appropriate emergency response system. Risk estimates are commonly reported simply by type of event, without regard to size, so it is difficult or impossible to isolate estimates for disastrous events alone. Since most losses are a consequence of small, or chronic, events, risk calculations are almost always strongly biased toward these lesser events.

Although risk calculations are generally of minor value in disaster preparedness planning, some jurisdictions will have occasion to be concerned with risk analyses. For such groups we suggest the National Safety Council's excellent annual publication, Accident Facts (Reference 13).

All government officials and staffs need to be aware of public attitudes toward risk. For realistic planning and implementation, it is important to know what, and how much, risk people are willing to accept. Public attitudes toward risk to life, for instance, have rather well defined variations. An annual risk of accidental death of one or more persons per 1,000 population is usually considered unacceptable, but a risk of one in one million is acceptable. By comparison, the actual risk of death from all causes is about one in 100 persons per year.

Factors affecting public acceptance of risk are compared below.

Comparison of levels of risk acceptance*

<u>Higher Acceptance Level</u>	Compared With	<u>Lower Acceptance Level</u>
Chronic conditions		Large, low-probability events
Very large, very low-probability events		Large, low-probability events
Voluntary risk		Involuntary risk
Natural causes		Human causes
Low intensity, diffuse effects		High intensity, concentrated effects
Warning available		No warning available

* Risk is assumed equal for each pair of parameters.

Source: Reference 4; ABAG.

EVALUATION OF HAZARDS

Hazards can be rated using the criteria discussed in the preceding section. The evaluation approach can be modified to meet the special needs or requirements of individual jurisdictions. It may be useful to start by listing all hazards that might lead to a disaster in a jurisdiction, and to note which of the disaster types given in Table 2 are believed to be insignificant in that jurisdiction.

History evaluation

If no disaster of the type under study has happened in the area in 100 years or more, and if conditions have not changed to increase the hazard, the historical rating is "nil". If such a disaster has occurred once in the past 100 years, a rating of "Sig" (for significant) is warranted. And if such a disaster has happened more than once in 100 years, the rating is "HIGH". The tabulation below shows how ratings should be modified to reflect changes that influence the hazard.

<u>Direction of Change</u>	<u>Number of Occurrences of Disaster of This Type in Past Hundred Years</u>		
	<u>None</u>	<u>One</u> RATING	<u>More Than One</u>
To reduce hazard	nil	nil	Sig
Hazard unchanged	nil	Sig	HIGH
To increase hazard	Sig	HIGH	HIGH

Vulnerability evaluation

Estimates of vulnerability can be derived by overlaying risk maps (see Reference 12) on land use and population maps (as in Figure 2). Often, only a rough estimate can be made without great expense. However, the percent of property and percent of population vulnerable can be tabulated separately.

The vulnerability evaluation might look like this:

<u>Vulnerability</u>	<u>Evaluation</u>
Less than 1%	nil (insignificant)
1% - 10%	Significant
10% and up	HIGH

Maximum threat evaluation

The maximum threat posed by a hazard can be estimated using risk, land use, and population maps, as well as vulnerability information. To estimate maximum threat, consider the greatest percent damage to life and property that could occur from a single disaster. Districts of large cities or regions can be considered and evaluated separately.

<u>Maximum Threat</u>	<u>Evaluation</u>
Less than 0.01%	nil (insignificant)
0.01% - 0.10%	Significant
0.10% and up	HIGH

Probability evaluation

The probability of a disaster can sometimes be estimated using available data, but often such estimates are only educated guesses. Thoughts and opinions that entered into development of the estimate can be recorded for future references. Probability can be evaluated in either (or both) of two ways:

1.	<u>Significance of 100-Year Event</u>	<u>Evaluation</u>
	Not a disaster	nil (insignificant)
	A disaster	Significant
	A major disaster*	HIGH
2.	<u>Chances per Year of a Disaster</u>	<u>Evaluation</u>
	Less than 1 in 1,000	nil
	Between 1 in 1,000 and 1 in 10	Significant
	Greater than 1 in 10	HIGH

Risk evaluation

Risk information is generally available only for areas considerably larger than a city. However, such information can be adjusted higher or lower as appropriate to reflect local conditions. The reasons for adjustments should be documented for future reference.

An example of a risk evaluation, in terms of the risk of deaths from, say, a major accident, might look like this:

<u>Annual Deaths per Million</u>	<u>Evaluation</u>
Less than 1	nil
1 - 100	Significant
100 and up	HIGH

*A major disaster is one that requires the use of several types of mutual aid from several jurisdictions, or one in which a state of emergency is declared by the Governor.

TABLE 2

Characteristics of potential Bay Area disasters

Disaster	Cause	Means of Damage	Seasonal or Time Constraints	Geo-graphical Limits	Geographical Extent
Earthquake	Natural	Energy ¹	No	Yes	County-Region
Landslide	Both	Energy	Likely	Yes	Local
Tsunami	Natural	Energy	No	Yes	Local-Nation
Flash Flood	Both	Energy	Likely	Yes	Local-Region
Slow-Rise Flood	Natural	Energy	Yes	Yes	Local-Region
Windstorm	Natural	Energy	Yes	No	Region
Hailstorm	Natural	Energy	Yes	No	Region
Snowstorm	Natural	Energy	Yes	Yes	Region
Human Epidemic	Natural	Poisoning	Likely	No	County-Nation
Animal Epidemic	Natural	Poisoning	Likely	No	County-State
Plant Epidemic	Natural	Poisoning	Likely	No	County-State
Rural Fire	Both	Energy	Yes	Yes	Local-Region
Urban Fire	Human	Energy	No	Yes	Local
Levee/Dam Failure	Both	Energy	No	Yes	Local-Region
Aircraft Wreck	Both	Energy	No	No	Local
Train Wreck	Human	Energy	No	Yes	Local
Shipwreck	Both	Energy	No	Yes	County-Region
Vehicle Wreck	Human	Energy	No	Yes	Local
Building Collapse	Human	Energy	No	Yes	Local
Power Failure	Both	Other	Likely	Yes	Local-State
Gas Failure	Both	Other	Likely	Yes	Local-State
Water Failure	Both	Other	Likely	Yes	Local-State
Chemical Spill	Human	Poisoning	No	Yes	Local-Region
Nuclear Spill	Human	Poisoning	No	Yes	Local-Region
Oil Spill	Both	Poisoning	No	Yes	Local-Region
Air Pollution	Both	Poisoning	Yes	Yes	County-Region
Water Pollution	Both	Poisoning	No	Yes	County-Region
Civil Disturbance	Human	Other	No	Yes	Local-Region
Nuclear War	Human	All	No	No	Region-Nation

1. Energy = Energy Release

Source: ABAG.

<i>Intensity Distribution</i>	<i>Forecasts</i>	<i>Warning</i>	<i>Warning Time</i>	<i>Rate of Onset</i>	<i>Predicta- bility of Intensity</i>	<i>Duration of Impact</i>
<i>Spotty</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Seconds</i>	<i>Poor</i>	<i>Sec-Days</i>
<i>Uniform</i>	<i>Fair</i>	<i>No</i>	<i>None</i>	<i>Sec-Days</i>	<i>Fair</i>	<i>Sec-Days</i>
<i>Spotty</i>	<i>Poor</i>	<i>Yes</i>	<i>Min-Hrs</i>	<i>Minutes</i>	<i>Poor</i>	<i>Minutes</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Sec-Min</i>	<i>Good</i>	<i>Minutes</i>
<i>Uniform</i>	<i>Good</i>	<i>Yes</i>	<i>Hrs-Days</i>	<i>Hrs-Days</i>	<i>Good</i>	<i>Hrs-Days</i>
<i>Spotty</i>	<i>Good</i>	<i>Yes</i>	<i>Hours</i>	<i>Hours</i>	<i>Fair</i>	<i>Hrs-Days</i>
<i>Spotty</i>	<i>Good</i>	<i>Yes</i>	<i>Hours</i>	<i>Minutes</i>	<i>Fair</i>	<i>Min-Hrs</i>
<i>Spotty</i>	<i>Good</i>	<i>Yes</i>	<i>Hours</i>	<i>Hours</i>	<i>Fair</i>	<i>Hrs-Days</i>
<i>Uniform</i>	<i>Fair</i>	<i>Yes</i>	<i>Days</i>	<i>Days</i>	<i>Poor</i>	<i>Days</i>
<i>Uniform</i>	<i>Fair</i>	<i>Yes</i>	<i>Days</i>	<i>Days</i>	<i>Poor</i>	<i>Days</i>
<i>Uniform</i>	<i>Fair</i>	<i>Yes</i>	<i>Days</i>	<i>Days</i>	<i>Poor</i>	<i>Days</i>
<i>Uniform</i>	<i>Good</i>	<i>No</i>	<i>None</i>	<i>Min-Hrs</i>	<i>Good</i>	<i>Hrs-Days</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Min-Hrs</i>	<i>Fair</i>	<i>Hrs-Days</i>
<i>Uniform</i>	<i>Fair-Poor</i>	<i>No</i>	<i>None</i>	<i>Sec-Hrs</i>	<i>Good</i>	<i>Min-Hrs</i>
<i>Either</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Seconds</i>	<i>Poor</i>	<i>Seconds</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Seconds</i>	<i>Poor</i>	<i>Seconds</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Seconds</i>	<i>Poor</i>	<i>Seconds</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Seconds</i>	<i>Poor</i>	<i>Seconds</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Sec-Hrs</i>	<i>Fair</i>	<i>Sec-Hrs</i>
<i>Uniform</i>	<i>Poor-Fair</i>	<i>No</i>	<i>None</i>	<i>Seconds</i>	<i>Good</i>	<i>Sec-Days</i>
<i>Uniform</i>	<i>Fair</i>	<i>Yes</i>	<i>Min-Hrs</i>	<i>Min-Hrs</i>	<i>Good</i>	<i>Hrs-Days</i>
<i>Uniform</i>	<i>Fair</i>	<i>Yes</i>	<i>Hrs-Days</i>	<i>Hrs-Days</i>	<i>Good</i>	<i>Hrs-Days</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Sec-Hrs</i>	<i>Poor</i>	<i>Sec-Days</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Sec-Hrs</i>	<i>Poor</i>	<i>Sec-Days</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Sec-Hrs</i>	<i>Fair</i>	<i>Sec-Hrs</i>
<i>Uniform</i>	<i>Fair</i>	<i>Yes</i>	<i>Hours</i>	<i>Hours</i>	<i>Fair</i>	<i>Hours</i>
<i>Uniform</i>	<i>Poor</i>	<i>No</i>	<i>None</i>	<i>Min-Hrs</i>	<i>Fair</i>	<i>Hrs-Days</i>
<i>Either</i>	<i>Fair</i>	<i>Yes</i>	<i>Hours</i>	<i>Hours</i>	<i>Fair</i>	<i>Hrs-Days</i>
<i>Uniform</i>	<i>Fair</i>	<i>Yes</i>	<i>Hours</i>	<i>Seconds</i>	<i>Poor</i>	<i>Hrs-Days</i>

RISK REDUCTION MEASURES

Three ways to reduce risk are considered here:

- Type I, hazard reduction (subdivided into IA, hazard avoidance, and IB, hazard mitigation). These include measures designed to avoid a hazard or to reduce vulnerability to its possible effects on life and property. Such measures are preventive in intent.
- Type II, disaster preparedness and response. Type II measures are intended to save lives and property during the emergency phase of a disaster. They are emergency operations centered.
- Type III, postdisaster recovery. These measures are designed to hasten recovery from a disaster and to reduce future risk to life and property. They require planning and action before a disaster occurs, for maximum effectiveness. They are restorative and corrective measures. Because they do not protect existing life and property, they are not considered in the evaluation of hazards.

Each of these measures can be considered separately. Measures in each category can be evaluated to the degree warranted, and an "average" evaluation of the type of risk reduction measure can be derived using the guidelines given below. A listing of risk reduction measures is given in Table 3.

<u>Findings</u>	<u>Evaluation</u>
1. Little can be done to reduce risk further. Almost all applicable measures are being taken and are considered effective.	Good
2. Measures currently implemented are generally satisfactory and are approximately as effective as those in use in other parts of the Bay Area.	Average
3. Existing measures can be improved substantially or additional measures can be taken to reduce risk substantially.	IMPROVABLE

TABLE 3

Examples of risk reduction measures

TYPE	MEASURES
Type I - Hazard Reduction	● Develop and adopt <u>comprehensive</u> safety elements in general plans. ● Periodically update safety-related elements of general plans, making use of new information on local conditions, recent research results, etc. ● Zone or rezone to avoid identified hazards areas. ● Adopt ordinances to provide for inspection, rapid amortization, and/or condemnation of real estate in hazardous locations. ● Perform capability studies of lands planned for development (or make detailed studies of hazards). ● Adopt building codes that stipulate use of proven protective designs. ● Enforce safety and disaster mitigation aspects of building codes. ● Build or remodel vital facilities (schools, hospitals, emergency operations centers) to resist the impacts of disaster. ● Identify hazardous structures and structures in hazardous locations. ● Provide information on hazards to prospective purchasers or lessees of real property. ● Undertake projects to reduce hazards (flood control, landslide abatement, firebreaks, etc.).

(continued)

TABLE 3 (continued)

TYPE	MEASURES
Type II - Disaster Preparedness and Response	● Develop and install systems for disaster forecasting, prediction, warning, etc. ● Organize staff and resources to cope with disaster (planning, adopting mutual aid plans, testing, training, exercising). ● Secure emergency response equipment and facilities (firefighting, rescue, communications, etc.). ● Obtain disaster protection facilities and systems (fallout shelters, assured water supplies, etc.).
Type III - Postdisaster Recovery	● Obtain insurance to cover disaster losses (flood, fire, earthquake, landslide, etc.). ● Plan to make maximum use of the opportunity to vacate hazardous areas. ● Implement recovery operations to remove damaged hazardous structures. ● Restore and remodel damaged structures to reduce hazards.

SUMMARIZING EVALUATIONS

The evaluations of hazards can be presented in tabular form. An example of such a summary appears in Table 4. This type of table can form the basis for a report or presentation to aid in deciding which hazards are most important in your jurisdiction.

The evaluations of risk reduction measures can also be summarized in a table (as an example, see Table 5). It is then possible to determine what are the best types of measures to implement, and in what order of priority.

THE DECISION PROCESS

When planning for risk reduction, government officials and staffs should:

- Select the most important hazards.
- Select the best risk reduction measures to apply to these hazards.
- Establish a reasonable order of priority (or plan) for implementing these measures.

Early in the deliberation period, officials may wish to develop a general rationale for arriving at decisions. Three alternatives are (a) to use a scoring system, (b) to decide through discussion, and (c) to use a combination of (a) and (b).

Scoring system

Scoring systems are most useful in ranking hazards in terms of the criteria discussed earlier. Staffs will probably do the actual scoring, using guidelines approved by elected officials. It should be noted that scoring systems, used alone, usually do not help much in establishing plans for implementing risk reduction measures.

In a commonly used scoring system, each criterion is given an importance weighting factor from 1 to 10, with the most important criterion receiving the highest number.*

* A recent ABAG report on land capability weighs importance on a scale of expected costs (in dollars per acre) for geographically related hazards.

TABLE 4

Hazard evaluation summary

(for an example jurisdiction)

Hazard	Evaluation Rating				
	History	Vulnerability	Maximum Threat	Probability	Risk
Earthquake	Sig ^a	HIGH	Sig	HIGH	Sig
Landslide	HIGH	Sig	Sig	HIGH	nil ^b
Tsunami	nil	nil	nil	nil	nil
Storm	Sig	HIGH	nil	nil	nil
Flood	HIGH	Sig	HIGH	Sig	nil
Epidemic	nil	HIGH	HIGH	Sig	Sig
Fire	HIGH	HIGH	HIGH	Sig	Sig
Levee/Dam Failure	nil	nil	nil	nil	nil
Transportation	nil	HIGH	HIGH	nil	HIGH
Utilities Failure	nil	Sig	Sig	nil	nil
Toxic Materials	nil	HIGH	Sig	Sig	nil
Pollution	nil	HIGH	HIGH	nil	Sig
Civil Disturbance	nil	HIGH	Sig	Sig	Sig
Nuclear War	nil	HIGH	HIGH	nil	HIGH

a. Sig = significant
b. nil = negligible, or unimportant

Source: ABAG.

TABLE 5

Risk reduction measures summary

(for an example jurisdiction)

<i>Hazard</i>	<i>Type of Measure</i>		
	<i>Avoid (IA)</i>	<i>Mitigate (IB)</i>	<i>Prepare (II)</i>
<i>Earthquake</i>	--	IMPROVABLE	Average
<i>Landslide</i>	--	Average	Average
<i>Tsunami</i>	--	--	--
<i>Storm</i>	--	Average	IMPROVABLE
<i>Flood</i>	IMPROVABLE	Average	Good
<i>Epidemic</i>	--	Average	Average
<i>Fire</i>	--	Good	Good
<i>Levee/Dam Failure</i>	--	--	--
<i>Transportation</i>	--	Average	Average
<i>Utilities Failure</i>	--	Average	Average
<i>Toxic Materials</i>	Average	Average	Average
<i>Pollution</i>	Average	Average	IMPROVABLE
<i>Civil Disturbance</i>	--	--	IMPROVABLE
<i>Nuclear War</i>	--	IMPROVABLE	IMPROVABLE

Source: ABAG.

Evaluations are given severity ratings, with both HIGH and IMPROVABLE receiving a rating of 10, the maximum. Severity ratings multiplied by importance weightings are totalled for each hazard and are adjusted to compensate for any missing values. The hazard with the highest score commands the highest priority for action.

Table 6 illustrates the method. Of the hazards shown, earthquakes scored highest and deserve the highest priority. Floods, scoring only slightly lower, also deserve a high priority. Thus the decision, if based only on the scoring system, and not considering other factors, should be to implement earthquake hazard reduction actions.

Discussions

To arrive at a decision through discussions, each point is examined and discussed in the context of risk reduction and "fit" with established policy. This process is most appropriate for addressing intangible factors such as public attitudes towards hazards and risk.

Scoring system/Discussion combined

The third alternative is to combine discussions with the use of a scoring system. Scoring systems offer a degree of objectivity that is hard to realize in discussion. But discussions have the advantage of being highly flexible, which scoring systems are not. Therefore, the well planned use of both methods seems to hold the most promise for reaching the best overall decision.

TABLE 6

Illustration of scoring method

(for an example jurisdiction)

Evaluation Criteria	Criteria Weights	Earthquake	Landslide	Tsunami	Storm	Flood	Scoring Elements
History	2	Sig 5 10	HIGH 10 20	nil 1 2	Sig 5 10	HIGH 10 20	Evaluation Rating ¹ Subscore ²
Vulnerability	5	HIGH 10 50	Sig 5 25	nil 1 5	HIGH 10 50	Sig 5 25	E R SS
Maximum Threat	10	Sig 5 50	Sig 5 50	nil 1 10	nil 1 10	HIGH 10 100	E R SS
Probability	7	HIGH 10 70	HIGH 10 70	nil 1 7	nil 1 7	Sig 5 35	E R SS
Risk	3	Sig 5 15	nil 1 3	nil 1 3	nil 1 3	nil 1 3	E R SS
Risk Reduction Type							
Avoid	10	-- -- --	-- -- --	-- -- --	-- -- --	IMPR 10 100	E R SS
Mitigate	4	IMPR 10 40	Avg 5 20	-- -- --	Avg 5 20	Avg 5 20	E R SS
Prepare	7	Avg 5 35	Avg 5 35	-- -- --	IMPR 10 70	Good 1 7	E R SS
Raw Score ³		270	223	27	170	310	
Adjustment ⁴ = 48		x48/38	x48/38	x48/27	x48/38	x48/48	
Adjusted Score ⁵		341	282	48	215	310	

1. Severity Rating assigned to Evaluation (HIGH = 10; Sig = 5; nil = 1; etc.).

2. Subscore = Criteria Weight x Severity Rating.

3. Raw Score = Sum of Subscores.

4. Adjustment (to account for missing values) = sum of all criteria weights divided by sum of criteria weights for a hazard.

5. Adjusted Score = Raw Score x Adjustment.

Source: ABAG.

APPENDIX*—

EARTHQUAKES

An earthquake is a shaking of the earth caused by the sudden slippage of rock below or at the earth's surface.

CHARACTERISTICS

Earthquakes usually occur suddenly and without warning. When the slippage is near and at the earth's surface, it can be seen as the movement of active geologic faults. (Sometimes such faults had previously been considered inactive.)

A major earthquake episode involves many shocks that can occur at intervals over a period of several weeks. The first shock is not necessarily the major shock. The effects of a damaging earthquake are almost always felt over a wide area (including several counties, for instance); damage is widespread but spotty.

CONSEQUENCES

Both the direct and the indirect effects of a quake damage property and injure people. Earth movement along a fault damages all structures that lie across the fault. Such movement can rupture pipelines, offset roads and rail lines, and damage or destroy aboveground structures. The sudden movement of the earth shears and crushes building frames, topples towers, knocks parapets loose, breaks windows, wracks building frames, and even throws people and (sometimes massive) objects around. Death, injury, and damage can occur at considerable distances from earthquake faults. Earth shaking can trigger many landslides simultaneously and can cause water-saturated soils to "liquefy."

**Appendices briefly describing the characteristics, consequences, history, vulnerability, maximum threat, probability, risk, emergency demands, and risk reduction measures are available from ABAG. The appendices refer to the following disasters:*

Earthquakes; Landslides; Tsunamis; Fires; Levee or Dam Failure; Nuclear War; Meteorological Hazards; Flood; Epidemic; and Civil Disturbance.

The appendix on earthquakes is included here as an example of the type of material which is available.

Quake effects can cause severe damage to transportation and utility systems. Numerous fires can be ignited simultaneously as a result of utility system damage; telephone communications by land line may be severely affected.

Electric power distribution systems may also suffer serious effects, and locally generated electric power may become the only power available.

Reservoirs can be damaged by earthquakes in several ways--by direct shaking of earth dams, by landslides into reservoirs that cause overtopping of dams, and by failure of the earth abutments supporting a dam.

An earthquake of Richter magnitude 7 might totally destroy weak masonry and frame buildings and inflict considerable damage on even well-built structures. Foundations might be cracked, underground pipes could be broken, railroad rails bent, and so on.

An earthquake of Richter magnitude 8.3 in the Bay Area would probably cause total destruction in some areas. Large objects might be dislodged from their foundations. Surface faulting could occur for as much as 200 miles along the fault, with displacements of about 20 feet in some areas, and shaking effects would be felt more than 300 miles from the epicenter.

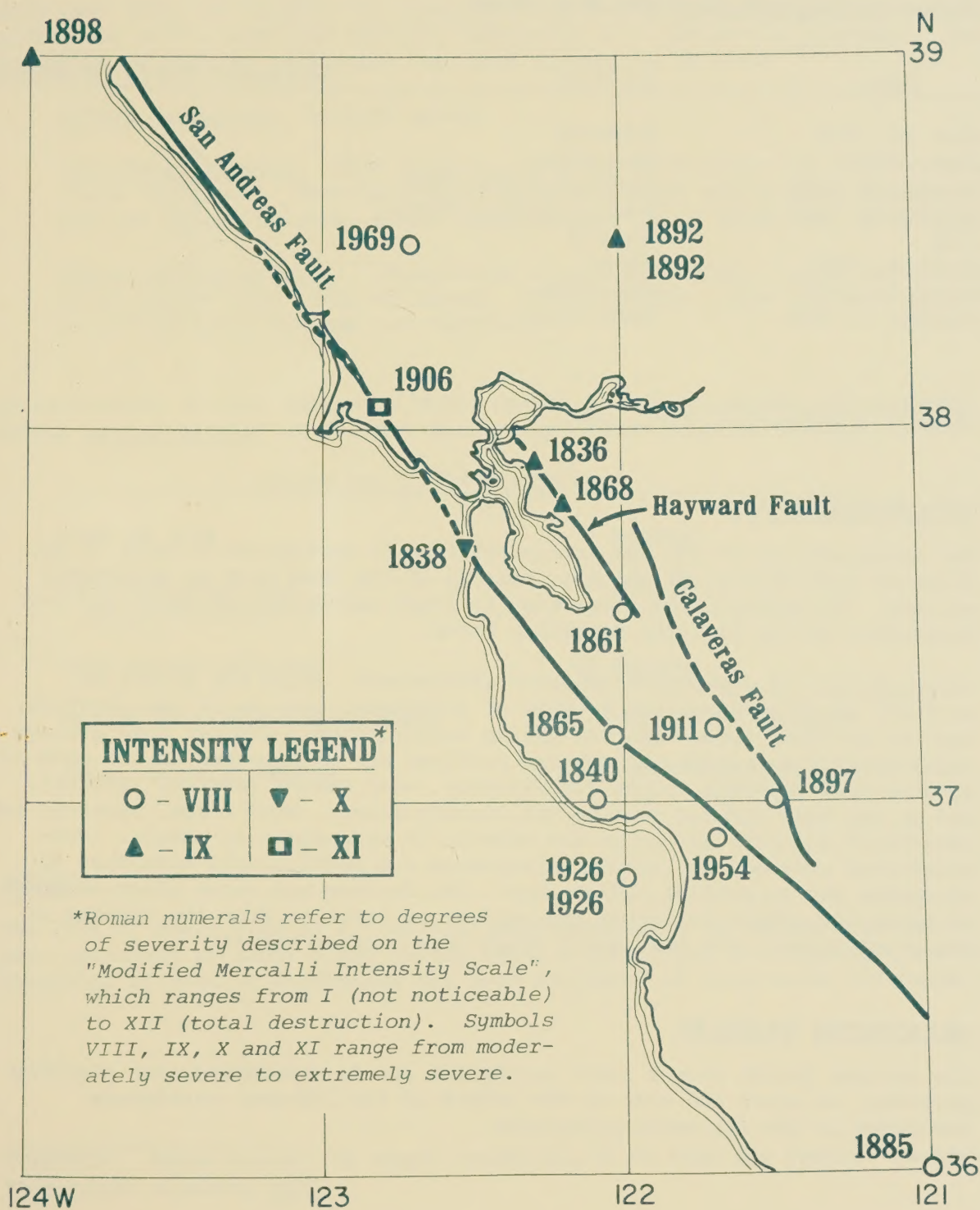
Loss of life could range from 2,500 to 10,000, injuries requiring hospitalization might total 40,000, and there could be as many as 300,000 lesser injuries. More than 400,000 people live in risk areas below dams in the Bay Area; it is estimated that as many as 100,000 of these people live below dams that might be damaged.

After an 8.3 Richter magnitude earthquake, some 30,000 to 60,000 Bay Area residents would require long-term housing because of damage to dwellings; the estimated property loss for single-family dwellings could be in excess of \$1 billion. Total property losses could exceed \$3.5 billion.

HISTORY

The most prominent of the many active faults in the Bay Area are the San Andreas, Hayward, and Calaveras faults. Figure A-1 shows the locations of these faults, and indicates the general locations of the epicenters of major earthquakes in the past 150 years. Table A-1 gives additional data on these quakes, including estimated Richter magnitudes. It is interesting--and perhaps unsettling--to note that in the 100 years before 1910 the region suffered four earthquakes estimated to be of Richter magnitudes greater than 7, and that no earthquakes as great as that have occurred since.

FIGURE A-1

San Francisco Bay Area earthquake history

Source: Altermissen, 1972.

TABLE A-1

Major earthquakes of the Bay Area

Date	Location	Estimated Richter Magnitude
June 10, 1836	Berkeley	8.0
June, 1838	Palo Alto	8.0
October 9, 1864	Santa Cruz-San Jose	6.0
October 9, 1865	Santa Cruz-San Jose	6.0
1868	Hayward	8.0
April 4, 1906	Olema	8.3
March 22, 1957	Daly City	5.3
October 2, 1969	Santa Rosa	5.6, 5.7

Source: Algermissen, 1972; ABAG.

VULNERABILITY

The vulnerability of the Bay Area population to earthquake effects is influenced considerably by the hour and day of the week when an earthquake strikes. In general, the population is least vulnerable at night and most vulnerable during daylight commuting hours.

Vulnerability of structures (whether aboveground, below the ground or surface) is largely related to type of structure, geology of the location, and the building codes observed during construction. Greater than average vulnerability to earthquake-related problems can be expected in the case of construction on steep slopes (landslides), near faults (surface rupture), and on Bay muds (ground shaking and liquefaction). Wood frame, masonry, and reinforced concrete buildings are especially vulnerable to damage. Non-reinforced concrete and masonry structures are particularly hazardous to occupants and to passing pedestrians. The facades and large glass windows of high-rise office buildings are subject to breakage from the flexing of the steel frames, and thus would constitute a great hazard.

MAXIMUM THREAT

The maximum threat from a large earthquake can be considered, for planning purposes, as about the same as the effect of the 100-year earthquake described in the following paragraphs.

PROBABILITY

Each year there is roughly one chance in 100 that the Bay Area will have an earthquake with a modified Mercalli intensity of X (about 8.3 Richter). The intensity of such an earthquake has been defined as follows:

Effect on people: General panic.

Structural effects: Most masonry and frame structures and their foundations destroyed. Some well-built wood buildings and bridges destroyed. Serious damage to dams, dikes, embankments. Rail lines bent slightly.

Miscellaneous effects: Conspicuous cracks in ground. Large landslides. Water thrown onto banks of canals, rivers, lakes. Sand and mud shifted horizontally on beaches and flatland.

An earthquake of this intensity would result in injury, death, and property damage approximately* as follows (excluding damage from dam failure):

<u>Damage per 1,000 population*</u>	
Loss of life	2 persons
Injuries requiring hospitalization	8 persons
Less severe injuries	60 persons
Damage to single-family homes	\$270,000 (1970 dollars)
Total property damage	\$700,000 (1970 dollars)

RISK

The risk of death from an 8.3 Richter magnitude quake in the Bay Area has been estimated at about 6,600 deaths among a population of 5 million, and the frequency of such an earthquake has been estimated at once every 170 years

*CAUTION: These values are rough estimates, to be used for general emergency operations planning only.

(Algermissen, 1972). Thus the annualized risk of death from this size of quake can be calculated:

$$\begin{aligned} \text{Risk} &= \frac{6,600}{5,000,000} \times \frac{1}{170} \\ &= 7.7 \text{ deaths/year/1 million population} \end{aligned}$$

EMERGENCY DEMANDS

A major earthquake in the Bay Area would impose immediate demands on all elements of the emergency organizations of the jurisdictions within the zone of severe shaking. Prompt backup support would be required from surrounding lightly damaged or undamaged areas. The heaviest demands would fall upon the communications systems, since much of the effective and coordinated response would depend on timely flow of information and instructions.

RISK REDUCTION MEASURES

Avoidance

Earthquakes cannot be avoided in the Bay Area. However, some of the more severe problems can be avoided by instituting land use controls that forbid construction on active faults and that control construction on unconsolidated bay mud, and/or by ordinances that require programmed modification or removal of structures already built in these areas.

Mitigation measures

The direct and indirect effects of earthquakes can be mitigated by the judicious application of geological and seismic information concerning urban areas and areas of proposed construction, together with the use of the best seismic engineering and construction techniques. Legislation is now in existence, and more is being proposed, to encourage mitigation measures.

Much can be done to improve the resistance of existing structures to collapse; for instance, the State of California Department of Transportation has implemented such a program to improve the safety of freeway overpasses. However, the large costs of such measures and the desire of the public to continue building close to present urban centers (and on steep hillsides, near faults, and on bay lands) detract from a fully effective mitigation program.

Preparedness

A major preparedness plan was implemented under a Federal Disaster Assistance Administration program in 1972 to prepare an earthquake response plan for the Bay Area. This planning process involves all Federal and state agencies that have response capabilities and all local governments that wish to participate. The program is continuing through the Federal-state On-Site Assistance (OSA) process and the State of California Office of Emergency Services (OES) Region II headquarters.

Effective preparedness measures for dealing with a large earthquake must take into consideration the extreme environment that will exist following the quake. Essential communications must be independent of land line telephones and central power; mutual aid plans should recognize that assistance forces may come from outside the Bay Area and that aid may have to be divided among several jurisdictions within the Bay Area. Major rescue plans must go into effect despite restrictions on ground movements and the difficulties of coordinating various types of emergency services (police, fire, public works, medical). Traffic control should be regional to facilitate the flow of essential traffic and discourage nonessential traffic. The welfare/inquiry system will be designed to provide service without imposing undue strain on limited long-distance telephone circuits.

Jurisdictions can gauge their levels of preparedness by determining the degree to which they have advanced in the various stages of each of the earthquake-related preparedness programs available (see Reference 10).

Appendix A References.

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2. Alfors, J. T., J. L. Burnett, and T. E. Gay, Jr., "Urban Geology. Master Plan for California," Bulletin 198, California Division of Mines and Geology, Sacramento, California, 1973.

This report discusses the nature, magnitude, and costs of geologic hazards in California and gives recommendations for their mitigation. A detailed and numerical methodology for setting priorities for the application of loss reduction measures is presented.

3. Algermissen, S. T. et al., "A Study of Earthquake Losses in the San Francisco Bay Area," U. S. Department of Commerce, National Oceanic and Atmospheric Administration, 1972.

This report provides emergency operations planners with a rational basis for planning earthquake disaster relief and recovery operations in the San Francisco Bay Area. Material in this report is intended for this use only.

4. Rasmussen, N. C., "Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants," WASH - 1400 (Draft), U. S. Atomic Energy Commission, August 1974.

In Chapter 2, this report discusses risk and the meaning of risk and in Chapter 6, the report discusses risks from natural and man-caused hazards.

The following four reports prepared by or under the direction of the University of California at Los Angeles provide the backup analysis to Chapter 6 of Reference 4.

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This book gives an excellent perspective on natural hazards that could have major disastrous consequences.

10. "Standards for Local Civil Preparedness," CPG 1-5, Defense Civil Preparedness Agency, U. S. Department of Defense, December 1972.

This document provides a convenient step-by-step method for evaluating local readiness to cope with major disasters.

11. "On-site Assistance, A Guide for Surveying and Developing Community Readiness," MP 63, Defense Civil Preparedness Agency, May 1972.
12. "San Francisco Bay Region Environment and Resources Planning Study," U. S. Geological Survey and U. S. Department of Housing and Urban Development, July 1975.

Three series of publications are produced by the SFBRs: Basic Data Contributions; Technical Reports; and Interpretive Reports. Copies and an index are available from:

Public Inquiries Office
U. S. Geological Survey
555 Battery Street
San Francisco, California 94111

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16. Dynes, R.R., E.L. Quarantelli, and G.A. Kreps, "A Perspective on Disaster Planning," TR-77, Ohio State University and College of William and Mary, December 1972.

About the Association

ABAG is owned and operated by the local governments of the San Francisco Bay Area. It was established in 1961 to meet regional problems through the cooperative action of its member cities and counties. At present, 85 of 93 cities and 7 of 9 counties in the Bay Area are members. Twenty-five special districts, regional agencies and other government agencies are non-voting, cooperating members. ABAG serves an area of about 7 thousand square miles and nearly 5 million citizens.

ABAG is the areawide comprehensive planning agency for the Bay Area. Its approved Regional Plan provides a policy guide for planning of the region's:

- | | | |
|---------------------------------|-----------------------|--------------------------|
| • air quality | • employment | • seaports |
| • airport systems | • growth management | • seismic safety |
| • community development | • housing | • solid waste management |
| • comprehensive health services | • human services | • transportation |
| • criminal justice | • ocean coastline use | • water resources |
| | • open space | • water quality |

Activities include developing long-range growth policies, adopting a regional housing element, initiating community development goals and policies, and implementing a plan to preserve natural resources and manage lands in the Bay Area. ABAG also keeps citizens informed and encourages citizen participation in regional planning.

A major program during 1976 and 1977 will be the development by ABAG and other agencies of areawide air and water quality management plans for the Bay Area. The \$4.3 million effort is funded by the Environmental Protection Agency under Section 208 of the Federal Water Pollution Control Act Amendments of 1972.

ABAG also works jointly with other regional agencies such as the Metropolitan Transportation Commission, the Bay Area Air Pollution Control District, the Bay Area Comprehensive Health Planning Council, the Bay Area Sewage Services Agency and the Coastal Zone Conservation Commissions.

ABAG policy is set by the General Assembly, which meets at least once a year. Delegates are elected officials from member cities and counties.

ABAG's Executive Board of 36 meets monthly to make operating decisions, consider grant applications, control expenditures and recommend major policies to the General Assembly. Executive Board members are appointed by County Boards of Supervisors, Mayors and City Councils. Membership on the Executive Board reflects the population size of each county.

The work of ABAG's staff of 110 is directed by the Executive Board and by policy committees that deal with various program and interest areas.

ABAG is the Federally designated areawide clearinghouse for the Bay Area. Reviews and comments on applications from local jurisdictions cover more than 150 different Federal assistance programs. During 1975, ABAG reviewed more than 1,000 local applications totalling \$555 million in Federal funds and \$748 million in total funds.

Development proposals with potentially significant effects on the region may be examined in their early stages -- before Federal grant applications are made -- by ABAG's system of hearing panels.

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